南京拓品微电子有限公司

NanJing Top Power ASIC Corp.

数据手册

DATASHEET

TP4057

(500mA Linear Li-Ion Battery Charger)

DESCRIPTION

The TP4057 is a complete linear charger for single cell lithium-ion batteries. This chip with reverse battery protection and power supply reverse connect protection. Its SOT23-6 package and low external component count make the TP4057 ideally suited for portable applications. Furthermore, the TP4057 can work within USB and wall adapter.

Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. Full charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The TP4057 automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage reaching.

When the input supply (wall adapter or USB supply) is removed, the TP4057 automatically enters a low current state, dropping the battery drain current to less than 1uA. The TP4057 can be put into shut down mode, reducing the supply current to 65uA. Other features include under voltage lockout, automatic recharge and two status pins to indicate charge termination.

FEATURES

- Programmable charging current up to 500mA
- No MOSFET, sense resistor or isolating diode required
- Lithium-ion batteries Reverse battery protection
- Maximize Charge Rate Without Risk of Overheating
- For Single Cell titanic acid Lithium-Ion Batteries
- Constant-current and constant-voltage control
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset Charge Voltage with 1% Accuracy
- Highest input can be up to 9V
- Automatic Recharge
- Two Charge Status Output Pins
- C/10 Charge Termination
- 40uA Supply Current in Shutdown
- Available in 6-Lead SOT-23 Package

APPLICATIONS

- Miniature lithium battery
- Cellular phone、PAD、MP3 player
- Bluetooth application

TYPICAL APPLICATION

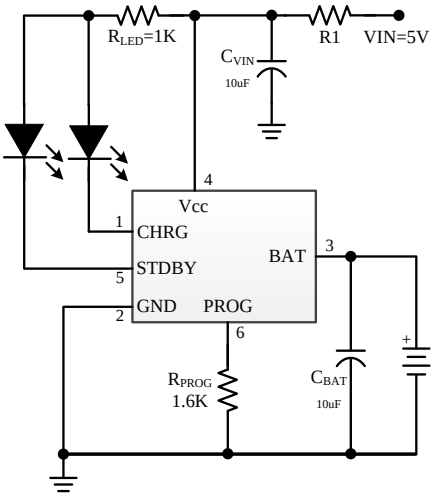
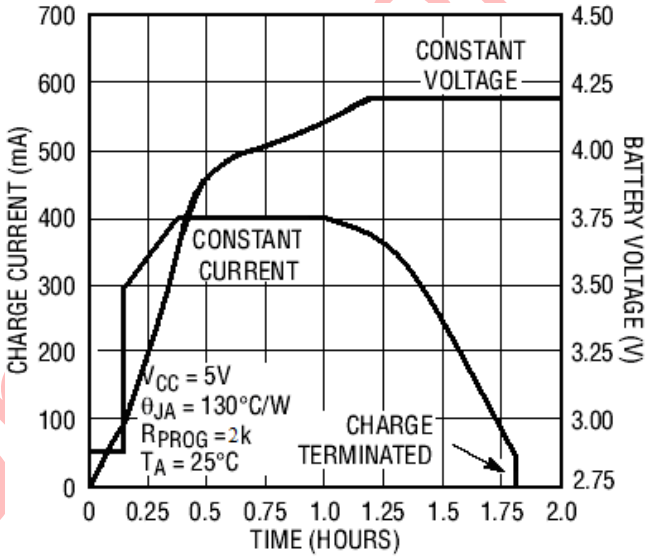


Figure 1 500mA Single lithium battery charger

Note: Proposed R1 dissipation resistor, it can get a larger charge current, and also improve the reliability of the machine. Resistance is selected according to the actual situation (0 ~ 0.6Ω).

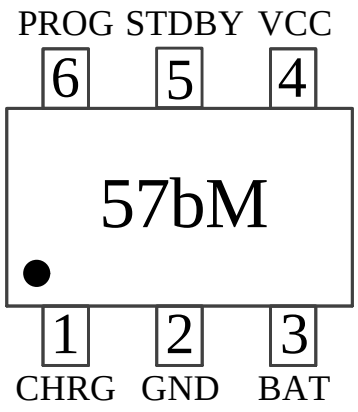
Full Charge Cycle (600mAh Battery)



ABSOLUTE MAXIMUM RATINGS

- VCC：-0.3V～9V
- PROG：-0.3V～VCC+0.3V
- BAT：-4.2V～9V
- CHRG：-0.3V～9V
- STDBY：-0.3V～9V
- BAT Pin Current：500mA
- PROG Pin Current：800uA
- Maximum Junction Temperature：145℃
- Operating Ambient Temperature Range：-40℃～85℃
- Storage Temperature Range：-65℃～125℃
- Lead Temperature(Soldering, 10sec)：260℃

PACKAGE DESCRIPTION



ORDER PART NUMBER
TP4057-42-SOT26-R
PART MARKING
57bM

Pin Description

CHRG (Pin1): Open Drain Charge Status Output When the battery is being charged, the CHRG pin is pulled low by the internal switch to indicate that charging is in progress; otherwise, the CHRG pin is in a high-impedance state.

GND (Pin2): Ground Terminal

BAT (Pin3): Battery Connection Pin This pin provides the charging current to the battery and adjusts the final float voltage to 4.2V. An accurate internal resistor divider for this pin sets the float voltage, which in the shutdown mode, the internal resistor divider is disconnected.

Vcc (Pin4): Positive Input Supply Voltage

This pin supplies power to the internal circuit. Vcc varies from 4V to 9V and should be bypassed by at least one 10μF capacitor. When Vcc drops to within 30mV of the BAT pin voltage, TP4057 enters low power sleep mode, dropping BAT pin's current to less than 2uA.

STDBY (Pin5): Open Drain Charge Status.

When the battery Charge Termination, the STDBY pin is pulled low by the internal switch to indicate that charging is in progress; otherwise, the STDBY pin is in a high-impedance state.

PROG（Pin6）: Charge current setting, charge current monitoring and shutdown pin

A precision of 1% of the resistance RPROG between the pin and ground to set the charge current. When in constant charge current mode, the voltage of the pin is maintained at 1V.

The PROG pin can also be used to turn off the charger. Setting the resistor to ground, a 2.5uA current internally pulls the PROG pin high. When the pin voltage reaches the shutdown threshold voltage 2.7V, the charger enters shutdown mode, charging is stopped and the input supply current to 40μA.Re-connecting R_{PROG} to ground will cause the charger to return to normal operation.

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at TA=25℃， V_{CC}=5V，unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{CC}	Input Supply Voltage		●	4.0	5	9.0	V
I_{CC}	Input Supply Current	Charge Mode, R_{PROG} = 10K	●		150	500	μA
		Standby Mode (Charge Terminated)	●		40	100	μA
		Shutdown Mode (R_{PROG} Not Connected, V_{CC} < V_{BAT}, or V_{CC} < V_{UV})	●		40	100	μA
V_{FLOAL}	Regulated Output (Float) Voltage	0℃≤TA≤85℃，I_{BAT}=40mA		4.158	4.2	4.242	V
I_{BAT}	BAT Pin Current (Except that VBAT=4.0V)	R_{PROG} = 10K, Current Mode	●	90	100	110	mA
		R_{PROG} = 2K, Current Mode	●	360	400	440	mA
		R_{PROG} = 1.6K, Current Mode	●	450	500	550	mA
		Standby Mode, VBAT = 4.2V			-2.5	-6	μA
		Shutdown Mode (R_{PROG} Not Connected)			±1	±2	μA
		Sleep Mode, V_{CC} = 0V			-1	-2	μA
					-1	-2	μA
I_{TRIKL}	Trickle Charge Current	V_{BAT}<V_{TRIKL}, R_{PROG}=10K	●	10	15	20	mA
V_{UV}	V_{CC} Undervoltage Lockout Threshold	From VCC Low to High	●	3.4	3.6	3.8	V
I_{TERM}	C/10 Termination Current Threshold	R_{PROG}=10K	●	8	10	12	mA
		R_{PROG}=1.6K	●	30	40	50	mA
V_{PROG}	PROG Pin Voltage	R_{PROG}=10K，Current Mode	●	0.9	1.0	1.1	V
V_{CHRG}	CHRG Pin Output versr Low Voltage	I_{CHRG} =5mA			0.3	0.6	V
I_{PROG}	PROG pin pull-up current				2.0		μA

OPERATION

TP4057 is a single lithium ion battery charger using constant current/constant voltage algorithm. It is capable of providing 500mA charging current (with the help of a thermally designed PCB layout) and an internal P-channel power MOSFET and thermal regulation circuit. No isolation diodes or external current detection resistors; Thus, the basic charger circuit requires only two external components. Not only that, the TP4057 can also get a working power supply from a USB power supply.

Normal charging cycle

A charging cycle begins when the Vcc pin voltage rises above the UVLO threshold level and a 1% precision setting resistor is connected between the PROG pin and ground or when a battery is connected to the charger output. If the BAT pin level is lower than the trickle charging threshold voltage, then the charger enters the trickle charging mode. In this mode, the TP4057 provides about 10% of the set charging current in order to raise the current voltage to a safe level for full current charging.

When the BAT pin voltage rises above the trickle charging threshold voltage, the charger enters the constant current mode, which provides a constant charging current to the battery. When the BAT pin voltage reaches the final floating charging voltage（4.2V）, TP4057 enters the constant voltage mode and the charging current begins to decrease. When the charging current drops to 1/10 of the set value, the charging cycle ends.

Charging current setting

The charging current is set by a resistor connected between the PROG pin and the ground. The setting resistor and charging current are calculated by the following formula, and the resistance value of the resistor is determined according to the required charging current:

Formula one: $R_{PROG} = \frac{1000}{I_{BAT}} * (1.3 - I_{BAT})$

(I_{BAT}>0.3A)

Formula two: $R_{PROG} = \frac{1000}{I_{BAT}}$

(I_{BAT}≤0.3A)

In applications larger than 0.3A, the chip heat is relatively large, and the temperature protection will reduce the charging current, and the test current in different environments is not completely consistent with the theoretical value calculated by the formula. In customer applications, an RPROG of an appropriate size can be selected as required.

R_{PROG} (K)	I_{BAT} (mA)
20	50
10	100
5	200
4	250
3	300
2	400
1.6	500

Charge termination

The charging cycle is terminated when the charging current drops to 1/10 of the set value after reaching the final floating charging voltage. This condition is detected by using an internal filter comparator to monitor the PROG pins. Charging is terminated when the PROG pin voltage drops below 100mV for more than t_{TERM} (generally 1.8ms). The charging current is locked off, and the TP4057 enters the standby mode. At this time, the input power current drops to 40μA. (Note: C/10 terminates in trickle charging and heat limiting modes).

When charging, the transient load on the BAT pin will cause the PROG pin voltage to drop

below 100mV temporarily between 1/10 of the DC charging current to the set value. The 20ms filter time (t_{TERM}) on the termination comparator ensures that transient loads of this nature do not cause premature termination of the charging cycle. Once the average charging current drops below 1/10 of the set value, the TP4057 terminates the charging cycle and stops providing any current through the BAT pin. In this state, all loads on the BAT pins must be powered by batteries.

In standby mode, TP4057 continuously monitors the BAT pin voltage. If the pin voltage drops below the recharging voltage threshold (V_{RECHRG}), another charging cycle starts and supplies current to the battery again. When manual restart of the charging cycle is performed in standby mode, either the charger must be cancelled and then the input voltage applied, or the charger must be turned off and restarted using the PROG pin.

Battery reverse connection protection function

The TP4057 has the lithium battery reverse connection protection function. The positive and negative poles of the lithium battery are reversely connected to the current output pin of the TP4057. The TP4057 will shut down to display the fault state, and there is no charging current. Both charging indicator pins are in high resistance state, and both LED lights are off. At this time, the leakage current of the reverse connected lithium battery is less than 0.8mA. Connect the reverse battery correctly, and TP4057 automatically starts charging cycle.

When the battery of the reverse connected TP4057 is removed, since the capacitive potential of BAT pin at the output end of TP4057 is still negative, the TP4057 indicator will not light normally immediately, and charging can be automatically activated only when the battery is connected correctly. Or wait for a long time to discharge the negative potential of the BAT terminal capacitor. If the BAT terminal potential is greater than zero volt, TP4057 will display the normal battery free indicator state.

In case of reverse connection, the power supply voltage should be about 5V of the standard voltage and should not exceed 8V. Excessive power supply voltage when the battery voltage is reversed, the chip differential voltage will exceed 10V, so the power supply voltage should not be too high when the battery voltage is reversed.

Charging status indicator （CHRG STDBY）

The TP4057 has two drain open state indicating outputs, CHRG and STDBY. When the charger is in the charging state, CHRG is pulled to the low level, and in other states, CHRG is in the high resistance state. When the battery is not connected to the charger, the CHRG output pulse signal indicates that the battery is not installed. When the external capacitance of BAT pin at the battery connection end is 10uF, the flicker cycle of CHRG is about 0.5-2 seconds.

Thermal Limits

If the chip temperature tries to rise above the preset value of about 120 ℃, an internal thermal feedback loop will reduce the set charging current. This function can prevent the TP4057 from overheating and allow the user to increase the upper limit of the power processing capacity of a given circuit board without the risk of damaging the TP4057. On the premise that the charger will automatically reduce the current under the worst case conditions, the charging current can be set according to the typical (not the worst case) ambient temperature. SOT power considerations will be further discussed in the "Thermal Considerations" section.

Undervoltage lockout

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until Vcc rises above the undervoltage lockout threshold. The UVLO circuit will keep the charger in shutdown mode. If the UVLO comparator jumps, the charger will not exit the shutdown mode until Vcc rises to 50mV higher than the battery voltage.

Manual stop

The TP4057 can be put into shutdown mode at any time during the charging cycle by removing the R_{PROG} (thus making the PROG pin float). This reduces the battery leakage current to less than 2μA and the power supply current to less than 50μA. Reconnecting the setting resistor initiates a new charging cycle.

Automatic restart

Once the charging cycle is terminated, the TP4057 immediately employs a comparator with 1.8ms filter time ($t_{RECHARGE}$) to continuously monitor the voltage on the BAT pin. When the battery voltage drops below 4.1V (roughly corresponding to 80% to 90% of the battery capacity), the charging cycle starts again. This ensures that the battery is maintained at (or near) a full charge and obviates the need to start a periodic charging cycle. During the recharging cycle, the CHRG pin output enters a strong pull-down state again, and the STDBY pin output enters a high resistance state again.

CHRG Status output pin

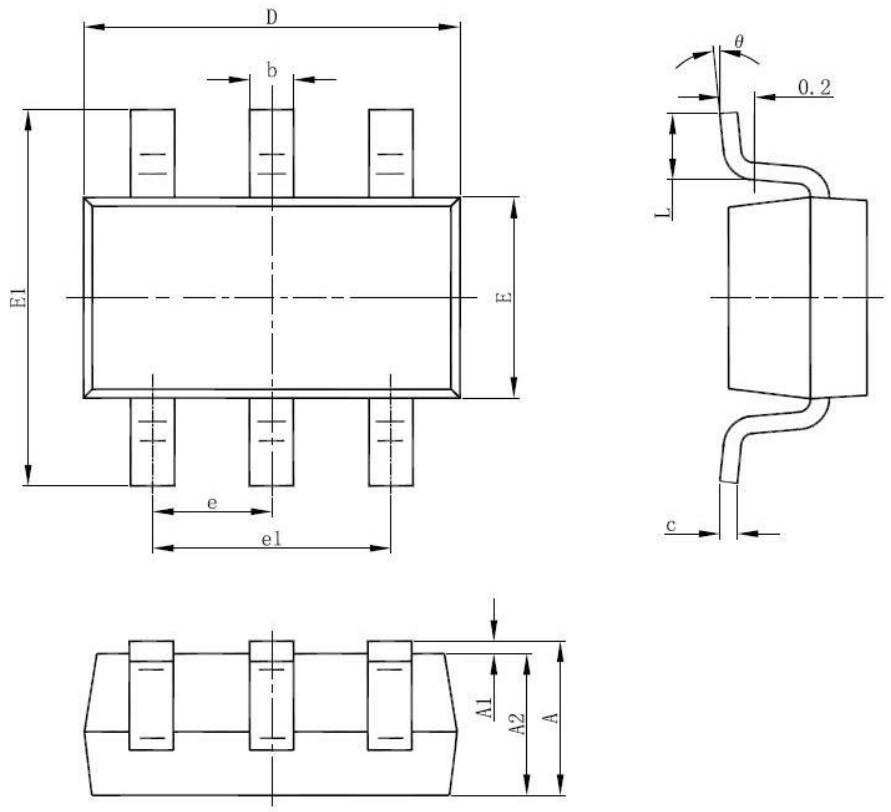
When a discharged battery is connected to the charger, the constant current part of the charging cycle starts, and the level of the CHRG pin is pulled to ground. CHRG pin can absorb current up to 10mA to drive an LED to indicate that the charging cycle is in progress.

When the battery is nearly full, the charger enters the constant voltage part of the charging cycle, and the charging current starts to drop. When the charging current drops to 1 /10 less than the set current, the charging cycle ends and the high resistance state is forced down to replace it, indicating that the charging cycle has ended. If the input voltage is removed or dropped below the undervoltage lockout threshold, the CHRG pin will also become high impedance. With a pull-up resistor, a microprocessor can detect these two states from this pin.

To detect when TP4057 is in charging mode, N-channel MOSFET pulls this pin to low level when 100k pull-up resistor is used. Once the charging cycle is terminated, the N-channel MOSFET is turned off, and the CHRG pin is a high impedance IN pin, which will then be pulled to the high level by a 100k pull-up resistor. Of course, in case of undervoltage lockout and insufficient input voltage, the IN pin will also be pulled to the high level, indicating that the device is in a UVLO state.

Packaging description

SOT-23-6L PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

Other Typical Applications

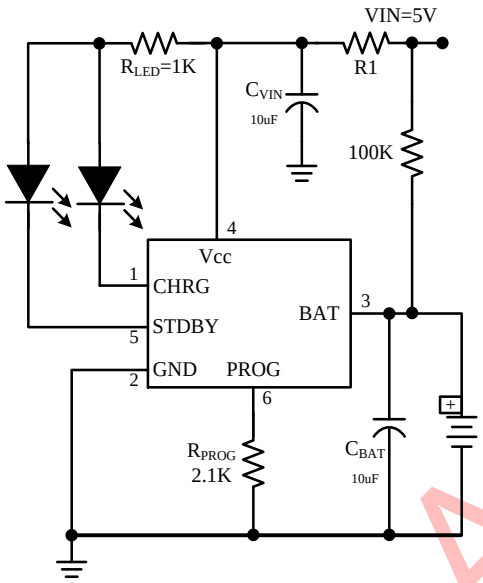


Figure 4 Single lithium battery charging application diagram when no battery red light is off